Tree Identification in the Sahel using NDVI Thresholding

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Background

Over the last century, the Earth's climate has changed drastically as the rate of carbon emissions has skyrocketed due to the burning of fossil fuels. Since 1959, the fraction of emissions that accumulates in the atmosphere has remained unchanged at 44%, while the remaining uptake of carbon has been through a balance of ocean and terrestrial processes.[1] Many climate studies have focused on the influence of oceans and tropical rainforests in the concentration of atmospheric CO_2 concentration, in which it has been shown that the mean sink is dominated by the highly productive lands (tropical rainforests) and oceans. However, a recent study showed that the trend and interannual variability of the terrestrial sink are dominated by semi-arid ecosystems, when compared using the Net Biome Productivity (NBP).[2]

The Sahel is a semi-arid zone in Africa that spans from the West African coast of the Atlantic Ocean to the Red Sea. It is classified as a transitional region between the Sahara and the Sudanian Saharra which is characterized by shrubs and low tree coverage because of a long dry season and a 2-3 month wet season. In 2000, 19% of the carbon available was consumed for food and fuel leading to deforestation and landscape degradation. As a result of this degradation, has caused food scarcities that are compounded by the political conflicts in the region as well as the shortening of the wet season due to climate change.[1]

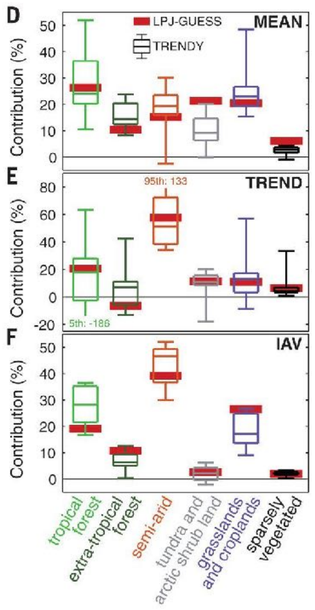


Figure 1. Global and regional NBP mean, trend, and variations (1982–2011) (Ahlström et al., 2015, p.896)

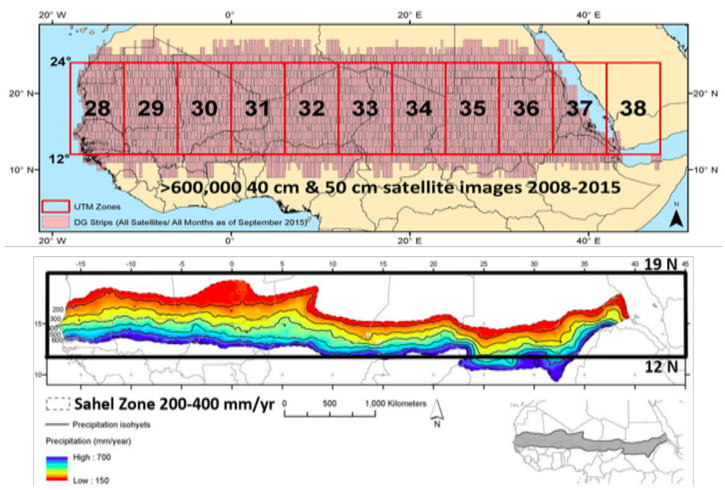
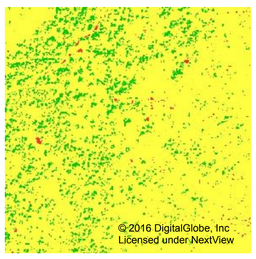
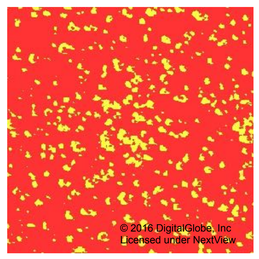
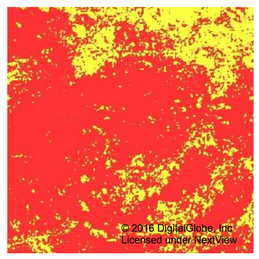
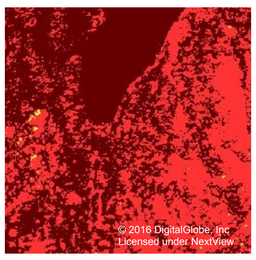
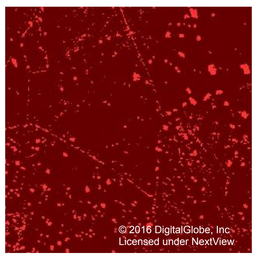
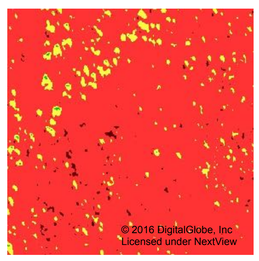


Figure 2 & 3. Existing DigitalGlobe Strips across Sahel with Rain Isocline (Katherine Melocik and Compton Tucker, 2017)

Methods

Six images from a dataset of the Senegalese Sahel were chosen based on the degree off nadir, with the half meter resolution imagery coming from the WorldView 2 and QuickBird 2 satellites. The images were pansharpened, from which a layer was created of the Normalized Difference Vegetation Index (NDVI) which is an indicator of live green vegetation. These NDVI values were hand tested to find a threshold at which trees were differentiated from the background, including grass and shadows. This was repeated for a low and high value of satellite nadir. Using these values as the high, medium, and low thresholds, the NDVI images were filtered such that there would be four colors which represented ranges in NDVI that were constant across the images using the Geospatial Data Abstraction Library (GDAL). The area of each threshold were calculated from the thresholded images. In order to visualize these thresholds, 62,500 square meter areas were exported from areas of each image.

Results

Sample of Image			
Percentage of Total Image Above NDVI Threshold	• NDVI = 0.40: 0.0000221414 • NDVI = 0.25: 0.0058311919 • NDVI = 0.16: 0.8914178829	• NDVI = 0.40: 0.0000936277 • NDVI = 0.25: 0.4983563973 • NDVI = 0.16: 0.9999861372	• NDVI = 0.40: 0.0000696749 • NDVI = 0.25: 0.959725777 • NDVI = 0.16: 0.9999999418
Thresholded NDVI Image	• Satellite: WorldView 2 • Date: Dec. 10, 2010 • Off-Nadir: 0.3	• Satellite: WorldView 2 • Date: Dec. 20, 2015 • Off-Nadir: 15.9	• Satellite: WorldView 2 • Date: Nov. 24, 2013 • Off-Nadir: 43.9
Sample of Image			
Percentage of Total Image Above NDVI Threshold	• NDVI = 0.40: 0.4893391084 • NDVI = 0.25: 0.9987016352 • NDVI = 0.16: 0.9999999867	• NDVI = 0.40: 0.9012131083 • NDVI = 0.25: 0.9997660757 • NDVI = 0.16: 1	• NDVI = 0.40: 0.0293634502 • NDVI = 0.25: 0.8973700993 • NDVI = 0.16: 0.9975561939
Thresholded NDVI Image	• Satellite: QuickBird 2 • Date: Jan. 8, 2008 • Off-Nadir: 0.9	• Satellite: QuickBird 2 • Date: Dec. 15, 2012 • Off-Nadir: 15.9	• Satellite: QuickBird 2 • Date: Nov. 27, 2013 • Off-Nadir: 43.9

NDVI Range by Color:

	-1.0 - 0.16		0.25 - 0.40
	0.16 - 0.25		0.40 - 1.00

Discussion and Conclusions

NDVI ranges are extremely sensitive across different satellite imagery which means that using simple thresholding techniques across a large dataset does not give consistent visual or quantitative results. The current process for identifying trees includes complex clustering algorithms to identify individual trees, which meant that there was a hope that a simpler approach would lead to a quicker result while maintaining meaningful accuracy in prediction. The need for hand picking the NDVI threshold means that unless there was an algorithm that takes into account the dynamic range, this approach is not feasible due to cost and time considerations

This particular approach may have value in background filtering, but in order to be useful, the issue of dynamic NDVI range has to be taken into consideration. From the small dataset of examples used in this thresholding project, it is unlikely that there is a simple relationship between NDVI range and degrees off nadir.

Future Work

Future work that I will continue to work on attempts to solve this runtime cost problem through Machine Learning techniques. These techniques would use hand sampled training data that has already been create in order to identify trees, which has intentions in a similar vein to this NDVI thresholding. Both approaches hope to simplify the processing of large amounts of data by finding an equation that can be applied to all NDVI images.

Acknowledgements

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References
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2. Abdi, A. M., Seaquist, J., Tenenbaum, D. E., Eklundh, L., and Ardö, J.: The supply and demand of net primary production in the Sahel, Environ. Res. Lett., 9,